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Characterization of multi-way binary tables with uniform margins and fixed correlations

In many applied settings involving binary variables, practitioners typically rely on pairwise measures of dependence, such as correlations or agreement indices. However, when more than two variables are involved, these quantities do not uniquely determine the joint distribution. Instead, they define a family of admissible distributions that share the same pairwise structure while potentially differing substantially in their higher-order interactions.

In this work, we introduce a geometric framework to characterize the full set of joint distributions with fixed pairwise dependence and uniform margins, using the framework of discrete copulas, a recently introduced approach to modeling multivariate dependence. We show that this admissible set forms a convex polytope whose structure can be explicitly analyzed. In particular, we investigate its symmetries and identify its extremal elements, which represent limiting configurations of higher-order dependence consistent with the observed pairwise information.

We highlight the practical relevance of this framework through two motivating examples drawn from medical and psychometric studies, where only partial dependence information is available. These examples illustrate how different admissible joint distributions may lead to substantially different conclusions, despite agreeing on all pairwise measures.

By enabling a systematic exploration of the full admissible set, our approach may be useful for applications in simulation and missing data imputation, where accounting for multiple compatible dependence structures can be important.

Special/ Invited session

Classification

Mainly methodology

Keywords

Contingency tables, Discrete copulas, Odds ratios

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